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Visual acuity affected by display lumination and surrounding illumination

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ABSTRACT

In this experiment, an effect of ambient illumination and luminance of display on visual acuity was carried out. The set of Thai letter chart in negative and positive polarities were used for visual acuity test. The letters were presented on the LCD display. The experimental conditions included combination of five illuminance levels of the room and six luminance levels of the display. The results showed that a visual acuity was improved with high luminance of display and low illuminance of surrounding. Furthermore, the proper ration between surrounding illuminance and display luminance is approximately 0.6. Our result shows a basic knowledge to express illuminance and luminance effect on visual performance as a practical application tool for display maker.

1. INTRODUCTION

It is well known that illumination is one of the critical factors influencing visual acuity. In tone reproduction, color images in dark surround need higher contrast than the images in light surround. Fairchild (1995) reported that there is more detail about the surround effect on perceived colorfulness. Nowadays, new media play an important role in our life. We spend a time to using media on digital devices. (2013) According to the International Data Corporation forecasts, worldwide sales of tablets to reached 195.4 million units in 2013 which was a 68 percent increase on 2012 sales number and tablets will grow 19.4% in 2014. Ambient light sensors are used to automatically adjust the brightness of the display in electronic devices. The sensor can adjust a display's backlight, which improves user experience and power savings by optimizing the display's view ability. Several factors are said to be responsible for visual acuity; character types and size, achromatic and chromatic contrast, visual duration, visual distance and so on. So far various studies have been carried out to invesitgae the factors that influence visual acuity on monitor display. Due to visual performance and saving energy aspect, hence, this study aims to investigate effects of surrounding illuminance and luminance of display.

2. EXPERIMENT

2.1 Experiment booth

As shown in Figure 1, the apparatus was composed of subject's room and test chart's room separated by a wall having a window. The subject's room was 1.3 x 2 x 2 m^3 (W x L x H) and a wall inside the room was covered with wallpaper of about N9 and illuminated by adjustable fluorescent lamps. The intensity of the lamps was adjusted by a light controller and the room illuminance was measured by an illuminometer placed on a shelf below the test stimulus at a distance of 44 cm. Many objects such as artificial flowers, dolls, books and a clock were put into

Thai characters used as test stimuli varied in different sizes of character height. The test stimuli were presented on LCD display. Both of negative and positive polarities were applied in the experiment. The experimental conditions were composed of the combination of 6 intensities of LCD display luminance (30, 47, 75, 120, 190, and 260 cd/m^2) and 5 intensity of subject's room illuminance levels (100, 200, 500, 1000, and 2000 lx).

Three subjects took part in the experiment. Their ages ranged from 20 to 25 years. The subject was asked to do a visual acuity test. Within each stimulus, 10 random characters of same size in the same line were presented in 30 experimental conditions for subjects read out and report. Each subject repeated 3 times of all experiment sessions.

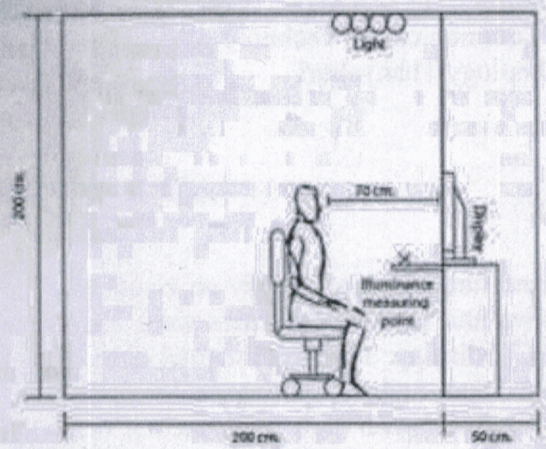

Figure 1. Schematic diagram of the apparatus.

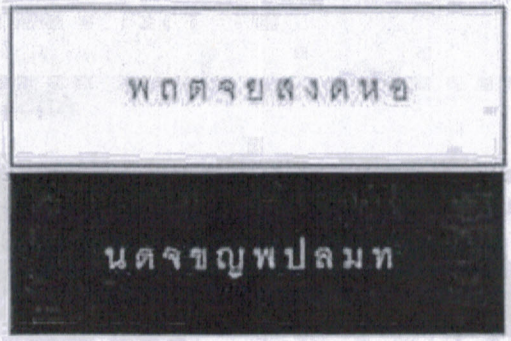

Figure 2. Thai character charts in (upper) negative polarity and (lower) positive polarity.

3. RESUALS AND DISCUSSION

The numbers of characters correctly read by subjects is accumulated as percentage of readable characters. In figure 3, the characters presented on LCD display with 30 cd/m^2 of luminance intensity shows the mean results with increasing character height in both negative polarity and positive polarity. The results show that a higher font size results in a higher percentage of readable character. Our results agree with previous studies for PDA (Park and *et.al.*, 2008) and visual display terminal (Ayama and *et.al.*, 2007). Moreover, we found that the higher the luminance of display, the higher the percentage of readable character. Next, the results of six illumination of subject's room were compared. We found that a visual acuity was improved when the intensity of surrounding illuminance was decreased.

To investigate a possible variation of correct response score among different display luminance levels, the 90% seeing curves of each subject were acquired and the threshold character size curve was analyzed. Figure 4 (left) shows a negative polarity result of the threshold character size in different display luminance levels expressed on a logarithmic scale. As shown by the results, visual acuity was improved with increased display luminance level. The lower size of character required a high display luminance level for perfect visual acuity. In contrast to negative polarity, the higher character height was required for improving visual

acuity. In positive polarity when the display is brighter, the subject reported that a glare of the character edge is appeared. This effect gave a low visual acuity to the subject.

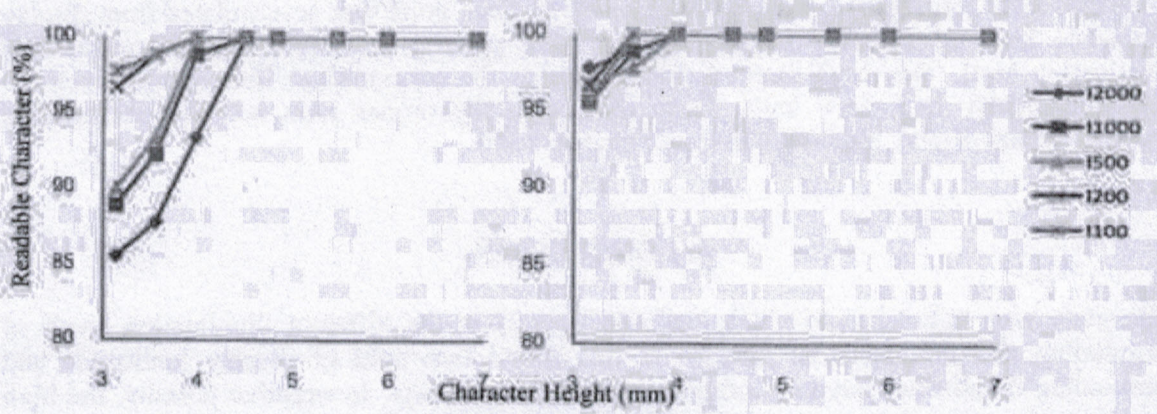

Figure 3. Mean of readable character in different sizes under display luminance of 30 cd/m^2. (left) negative polarity and (right) positive polarity.

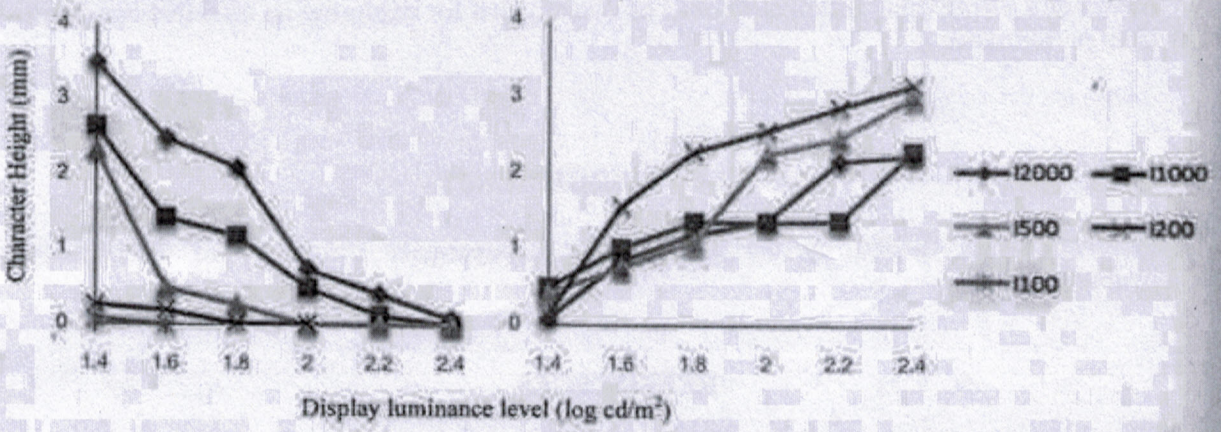

Figure 4. The 90% threshold character size curve of display luminance in different sizes of character. (left) negative polarity and (right) positive polarity.

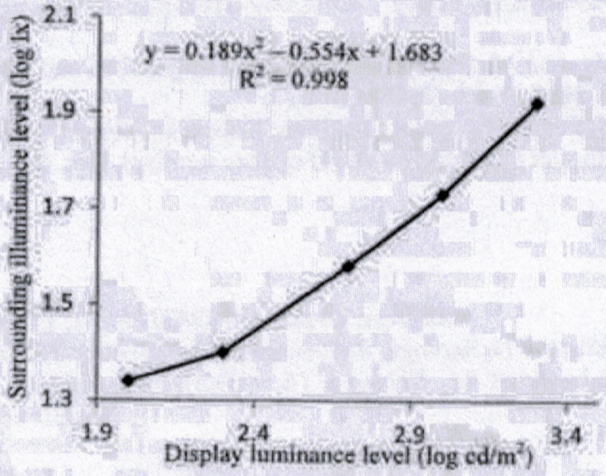

Figure 5. The result of proper surrounding illuminance level and display luminance level for intercept between negative polarity and possitive polarity.

Next, we sought the proper ratio between surrounding illuminance level and display luminance level. Figure 5 shows the result of proper surrounding illuminance level and display luminance level for negative and possitive polarities. Each point was accumulated from display luminance level of negative polarity and positive polarity intercept in each surrounding illumination level. The result showed that the higher the surroundings illuminance level, the higer the display luminance level. From the result, the proper ratio between surrounding illuminance and display luminance is approximately 1:0.6.

4. CONCLUSION

This study was undertaken to obtain the visual acuity in the different illumination levels of surrounding and luminance of display. It was found that both of display luminance and surrounding illuminance have an influence over a visual acuity. In negative polarity, the high display luminance and low surrounding illuminance gives the high visual acuity. In the other hand, the lower of display luminance and surrounding illuminance give the high visual acuity in positive polarity. Even thought a visual acuity was concerned in this study, a visual comfortable is importance. In a future work a visual comfortable and proper ration between display luminance and surrounding illuminance will be investigated for exploring an effective condition in visual performance.

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